ADA

ALCOHOL-TO-JET (ATJ) FUEL BLENDING STUDY

INTERIM REPORT
TFLRF No. 472

by
Scott A. Hutzler

U.S. Army TARDEC Fuels and Lubricants Research Facility
Southwest Research Institute® (SwRI®)
San Antonio, TX

for
Patsy Muzzell
U.S. Army TARDEC
Force Projection Technologies
Warren, Michigan

Contract No. W56HZV-09-C-0100 (WD24, Task 2.2)

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Approved by:

Gary Bessee

Gary B. Bessee, Director
U.S. Army TARDEC Fuels and Lubricants
Research Facility (SwRI®)

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14. ABSTRACT The U.S. Army sought to study the effect of blending highly iso-paraffinic ATJ blending stock into JP-8 in order to understand the effect ATJ fuel blends will have on ground vehicle engines and support equipment. This subtask under Work Directive (WD) 24 focused on specification and fit-for-purpose testing of various ATJ/JP 8 blends.			
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EXECUTIVE SUMMARY

Alcohol-to-Jet (ATJ) fuels are slowly making their way through the approval process at ASTM as candidate aviation fuels or blendstocks. To expand upon existing data, the U.S. Army sought to study the effect of blending the highly iso-paraffinic ATJ blending stock into JP-8. The objective of this was task was to generate baseline data for ATJ/JP-8 blends to support testing related to ground vehicles and support equipment. This subtask, under Work Directive (WD) 24, focused on specification and fit-for-purpose testing of various ATJ/JP 8 blends ranging from 0-100% ATJ. In general, most properties showed a linear trend relative to the blending. This is expected when blending hydrocarbons. The blend proportions provided a good span of important properties such as density, cetane number, and aromatic content. This matrix of data made it possible to select candidate blend ratios for further study in other subtasks under this WD. The data provided herein and the subsequent hardware evaluations will contribute to the overall approval process for ATJ fuels.

FOREWORD/ACKNOWLEDGMENTS

The U.S. Army TARDEC Fuel and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI), San Antonio, Texas, performed this work during the period July 2013 through September 2015 under Contract No. W56HZV-09-C-0100. The U.S. Army Tank Automotive RD&E Center, Force Projection Technologies, Warren, Michigan administered the project. Mr. Eric Sattler served as the TARDEC contracting officer's technical representative. Ms. Patsy Muzzell of TARDEC served as project technical monitor.

The authors would like to acknowledge the contribution of the TFLRF technical support staff along with the administrative and report-processing support provided by the TFLRF administrative staff.

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ACRONYMS AND ABBREVIATIONS

ATJ	Alcohol-to-Jet Alternative Fuel
DCN	Derived Cetane Number
JP-8	Jet Propulsion Fuel Number 8
WD	Work Directive

1.0 OBJECTIVE

Alcohol-to-Jet (ATJ) fuels are slowly making their way through the approval process at ASTM as candidate aviation fuels or blendstocks. Extensive testing, including flight tests, have already been undertaken. For this reason, the U.S. Army sought to study the effect of blending the highly iso-paraffinic ATJ blending stock into JP-8 in order to understand the effect ATJ fuel blends will have on ground vehicle engines and support equipment. This subtask under Work Directive (WD) 24 focused on specification and fit-for-purpose testing of various ATJ/JP-8 blends. The data from these analyses will be used in other subtasks studying the effects of these fuels on engine and fuel pump performance.

2.0 SAMPLE PREPARATION

Neat ATJ (SwRI AF-8639, CL13-5979) and Jet A (SwRI AF-8736, CL13-5980) was acquired from the U.S. Army in bulk for testing purposes. For this blending study, all samples were collected, blended, and stored in 5-gallon epoxy-lined fuel cans.

Six ATJ blends were prepared in 18-L quantities according to the blend ratios in Table 1. A blend at 25% ATJ was added to the original plan to accommodate other tasks under the WD.

In addition to the above blends, a 5-gallon epoxy-lined can of each blending component was set aside for testing. Each of the blends and the neat Jet A were additized to JP-8 according to Table 2.

Table 1. Blend Ratios

ATJ Volume %	Jet A Volume %	Sample ID
15	85	CL14-6111
25	75	CL14-6189
35	65	CL13-5982
50	50	CL13-5983
65	35	CL13-6068
85	15	CL13-5985

Table 2. JP-8 Additives

Additive	Amount
Stadis 450	2 mg/L
DCI-4A	9 mg/L
FSII	0.09 vol%

Testing of the eight samples was performed IAW Table 1 of MIL-DTL-83133H in addition to the following properties:

- Viscosity at 40 °C and 100 °C per ASTM D445
- Derived Cetane Number (DCN) per ASTM D6890
- Cetane Number per ASTM D613 (modified)
- Lubricity (BOCLE) per ASTM D 5001
- Lubricity (HFRR) per ASTM D 6079
- Density per ASTM D4052 @ 15 °C
- Distillation per ASTM D86
- Net Heat of Combustion per ASTM D4809
- Isentropic Bulk Modulus per the Acoustic-Adiabatic method at the following conditions:
    - 30 °C at 0 psi
    - 35 °C and 75 °C at 5-6 pressure points ranging from ~200-5000 psi

3.0 RESULTS AND DISCUSSION

The results for the ATJ and JP-8 blend study are tabulated below as follows:

- **Blendstock Results**
    - Table 3
- **ATJ / JP-8 blends**
    - Table 4
- **Speed-of-Sound and Bulk Modulus results for the blends**
    - Table 5 for 15, 25, 35% blends
    - Table 6 for 50, 65, 85% blends

- **Additional mini-blends used to assess the impact of excess Stadis 450**
    - Table 7
- **Additional mini-blends using a new Stadis 450 sample**
    - Table 8

As results started to return from the lab, it was noted that the electrical conductivity of the additized samples was unusually high. It was determined that the Jet A and the blends had been accidently over-additized to 2 mg/L of Stadis 450 rather than 1 mg/L. Since a good amount of data on these samples had already been generated, it was decided that the analysis would be completed and a few key properties that might be affected by the excess additive would be retested. Anecdotal evidence suggests that side-effects from over-additization with Stadis 450 may not appear below 3000 pS/m. However, the presence of any surfactants or detergents in the carrier solvent may impact water separation related tests. Coincidentally, one of the water reaction results and a few of the MSEP results were deemed questionable. To that end, smaller quantities of each blend (properly additized to 1 mg/L Stadis 450) were prepared to confirm the following properties: electrical conductivity, density, FSII content, water reaction, and microseparometer rating.

The results for those ATJ re-blends (Table 7) showed only marginal improvements. Postulating that the Stadis 450 sample might be bad, another round of small re-blends were prepared and analyzed for a subset of the test methods (Table 8). These results were still only marginally better than the previous analyses. The electrical conductivities were still well-above what might be expected for the treat rate. For the most part, the MSEP values were slightly more acceptable than seen previously but still nominally the same as might be expected for JP-8. The volumetric blend ratios (ATJ to JP-8) were confirmed by comparison to previous density values. The odd behavior of the static dissipater additive (SDA) might warrant a further, more detailed investigation of the fuel's additive response characteristics.

Table 3. Blendstock Results

Test	Method	Units	Sample ID CL13-5979 Results 100% ATJ	Sample ID CL13-5980 Results JP-8	MIL-DTL-83133H (Table I and A-II)
Water Reaction	**D1094**				
Volume change of aqueous layer		**mL**	1.0	0.0	
Interface condition		**rating**	1b	1b	1b max
Separation		**-**	2	2	
Copper Strip Corrosion (100°C, 2 hrs)	**D130**	**rating**	1b	1a	1 max
Smoke Point	**D1322**	**mm**	35.0	25.5	25.0 min
Saybolt Color	**D156**	**-**	28	29	report
Freeze Point (manual)	**D2386**	**°C**	<-80	-60.0	-47 max
Electrical Conductivity	**D2624**				
Temperature		**°C**	22.2	21.9	
Electrical Conductivity		**pS/m**	0	1110	150-600
JFTOT	**D3241**				
Test Temperature		**°C**	260	260	
ASTM Code		**rating**	1	1	<3
Maximum mmHg		**mmHg**	0.00	0.00	25 max
Acid Number	**D3242**	**mg KOH/g**	0.007	0.007	0.015 max
Existent Gum	**D381**	**mg/100mL**	10	1	7 max
Density	**D4052**				
15°C		**g/mL**	0.7575	0.7951	0.775-0.840
Density	**D4052C**				
5°C		**g/mL**	0.7646	0.8023	
15°C		**g/mL**	0.7575	0.7951	0.775-0.840
25°C		**g/mL**	0.7504	0.7877	
35°C		**g/mL**	0.7432	0.7803	
45°C		**g/mL**	0.7359	0.7729	
55°C		**g/mL**	0.7287	0.7654	
65°C		**g/mL**	0.7214	0.7580	
75°C		**g/mL**	0.7140	0.7504	
85°C		**g/mL**	0.7066	0.7429	
Kinematic Viscosity	**D445**				
100°C		**cSt**	0.75	0.68	
40°C		**cSt**	1.48	1.31	
-20°C		**cSt**	4.82	4.45	8.0 max
Lubricity (BOCLE)	**D5001**	**mm**	0.930	0.660	
Lubricity (HFRR) at 60°C	**D6079**	**µm**	698	676	
Fuel System Icing Inhibitor (FSII)	**D5006**	**vol %**	0.00	0.09	0.07-0.10
Particulate Contamination in Aviation Fuels	**D5452**				
Total Contamination		**mg/L**	0.30	0.30	1.0 max
Total Volume Used		**mL**	1000	1000	
Distillation	**D86**				
IBP		**°C**	174.1	173.6	
5%		**°C**	176.8	183.7	
10%		**°C**	177.7	186.9	205 max
15%		**°C**	178.1	189.3	
20%		**°C**	178.2	192.0	
30%		**°C**	179.2	197.1	
40%		**°C**	175.8	202.1	
50%		**°C**	180.5	206.5	
60%		**°C**	181.4	211.5	
70%		**°C**	183.6	217.2	
80%		**°C**	189.9	224.0	
90%		**°C**	214.8	234.1	
95%		**°C**	241.9	242.5	
FBP		**°C**	259.1	253.5	300 max
Residue		**%**	1.3	1.3	1.5 max
Loss		**%**	0.6	0.3	1.5 max

Table 3. Blendstock Results

Test	Method	Units	Sample ID CL13-5979 Results	Sample ID CL13-5980 Results	MIL-DTL-83133H (Table I and A-II)
			100% ATJ	JP-8	
T50-T10		°C	2.8	19.6	15 min
T90-T10		°C	37.1	47.2	40 min
Flash Point (Pensky Martin)	D93	°C	44.5	53.5	38 min
Cetane Index	D976	-	53.9	49.2	
Particle Count by APC (Cumulative)	ISO-4406				
>= 4µm(c)		class code	16	17	
>= 6µm(c)		class code	15	15	
>= 14µm(c)		class code	12	12	
>= 21µm(c)		class code	11	10	
>= 38µm(c)		class code	7	7	
>= 70µm(c)		class code	0	0	
Speed-of-Sound @ 35°C	SwRI				
184 psi		m/s	1175.2	--	
756 psi		m/s	1201.9	--	
1366 psi		m/s	1230.8	--	
2015 psi		m/s	1257.3	--	
3083 psi		m/s	1308.1	--	
3808 psi		m/s	1329.0	--	
4533 psi		m/s	1356.9	--	
5563 psi		m/s	1392.2	--	
Speed-of-Sound @ 75°C	SwRI				
222 psi		m/s	1031.0	--	
794 psi		m/s	1062.0	--	
1366 psi		m/s	1094.7	--	
2053 psi		m/s	1130.8	--	
2740 psi		m/s	1157.9	--	
3541 psi		m/s	1196.2	--	
4304 psi		m/s	1225.2	--	
5334 psi		m/s	1265.0	--	
Speed-of-Sound @ 35°C	SwRI				
222 psi		m/s	--	1264.8	
832 psi		m/s	--	1294.4	
1977 psi		m/s	--	1326.6	
2816 psi		m/s	--	1365.2	
3770 psi		m/s	--	1393.1	
4990 psi		m/s	--	1428.9	
5944 psi		m/s	--	1453.8	
Speed-of-Sound @ 75°C	SwRI				
184 psi		m/s	--	1108.3	
756 psi		m/s	--	1133.0	
1366 psi		m/s	--	1168.2	
2511 psi		m/s	--	1216.2	
3426 psi		m/s	--	1245.8	
4571 psi		m/s	--	1290.9	
5715 psi		m/s	--	1319.8	
Isentropic Bulk Modulus @ 35°C	SwRI				
184 psi		psi	149,859	--	
756 psi		psi	157,484	--	
1366 psi		psi	165,935	--	
2015 psi		psi	173,892	--	
3083 psi		psi	189,642	--	
3808 psi		psi	196,628	--	
4533 psi		psi	205,833	--	
5563 psi		psi	217,909	--	
Isentropic Bulk Modulus @ 75°C	SwRI				
222 psi		psi	111,354	--	
794 psi		psi	118,908	--	
1366 psi		psi	127,042	--	
2053 psi		psi	136,374	--	
2740 psi		psi	143,790	--	

Table 3. Blendstock Results

Test	Method	Units	Sample ID CL13-5979 Results	Sample ID CL13-5980 Results	MIL-DTL-83133H (Table I and A-II)
			100% ATJ	JP-8	
3541 psi		psi	154,372	--	
4304 psi		psi	162,898	--	
5334 psi		psi	174,815	--	
Isentropic Bulk Modulus @ 35°C	SwRI				
222 psi		psi	--	180,503	
832 psi		psi	--	189,866	
1977 psi		psi	--	200,836	
2816 psi		psi	--	213,736	
3770 psi		psi	--	223,720	
4990 psi		psi	--	236,804	
5944 psi		psi	--	246,317	
Isentropic Bulk Modulus @ 75°C	SwRI				
184 psi		psi	--	133,212	
756 psi		psi	--	139,986	
1366 psi		psi	--	149,678	
2511 psi		psi	--	163,538	
3426 psi		psi	--	172,729	
4571 psi		psi	--	186,854	
5715 psi		psi	--	196,528	
Heat of Combustion - Net Intermediate	D4809	MJ/kg	43.6	43.0	42.8 min
Sulfur-Mercaptan	D3227	mass %	<0.0003	0.0004	0.002 max
Derived Cetane Number	D6890				
Ignition Delay, ID		ms	20.505	4.317	
Derived Cetane Number		---	15.65	47.68	40 min
Cetane Number	D613	-	<19.4	46.9	
MSEP	D7224	rating	93	57	70 min
Aromatic Content	D1319				
Aromatics		vol %	0.7	16.8	8.0-25.0
Olefins		vol %	2.3	2.0	
Saturates		vol %	97.0	81.2	
Naphthalene Content	D1840	vol%	0.00	0.82	3.0 max
Hydrogen Content (NMR)	D3701	mass %	15.53	14.2	13.4 min
Sulfur Content	D4294	ppm	<100	997	3000 max

Table 4. Blend Results

Test	Method	Units	Sample ID CL14-6111 Results 15% ATJ	Sample ID CL14-6189 Results 25% ATJ	Sample ID CL13-5982 Results 35% ATJ	Sample ID CL13-5983 Results 50% ATJ	Sample ID CL13-6068 Results 65% ATJ	Sample ID CL13-5985 Results 85% ATJ	MIL-DTL-83133H (Table I and A-II)
Water Reaction	**D1094**								
Volume change of aqueous layer		**mL**	0.0	0.5	0.5	0.0	0.50	2.0	
Interface condition		**rating**	1b	1b	1b	1b	1b	2	1b max
Separation		**-**	2	2.0	2	2	2	2	
Copper Strip Corrosion (100°C, 2 hrs)	**D130**	**rating**	1A	1A	1A	1A	1A	1A	1 max
Smoke Point	**D1322**	**mm**	26.0	27.0	28.0	29.5	30.5	33.0	25.0 min
Saybolt Color	**D156**	**-**	27	27.0	29	28	27	30	report
Freeze Point (manual)	**D2386**	**°C**	-55.0	-57.0	-60.0	-62.0	-68.0	-78.0	-47 max
Electrical Conductivity	**D2624**								
Temperature		**°C**	22.2	23.9	21.6	21.6	21.3	20.5	
Electrical Conductivity		**pS/m**	660	470	1230	890	810	820	150-600
JFTOT	**D3241**								
Test Temperature		**°C**	260	260	260	260	260	260	
ASTM Code		**rating**	1	<1	1	1	1	1	<3
Maximum mmHg		**mmHg**	0	0	0	0	0	0	25 max
Acid Number	**D3242**	**mg KOH/g**	0.010	0.008	0.010	0.008	0.010	0.008	0.015 max
Existent Gum	**D381**	**mg/100mL**	1	2	1	<1	2	<1	7 max
Density	**D4052**								
15°C		**g/mL**	0.7896	0.7857	0.7820	0.7766	0.7710	0.7635	0.775-0.840
Density	**D4052C**								
5°C		**g/mL**	0.7969	0.7931	0.7892	0.7838	0.7782	0.7704	
15°C		**g/mL**	0.7896	0.7859	0.7820	0.7766	0.7710	0.7635	0.775-0.840
25°C		**g/mL**	0.7822	0.7786	0.7746	0.7694	0.7638	0.7563	
35°C		**g/mL**	0.7749	0.7712	0.7674	0.7621	0.7565	0.7491	
45°C		**g/mL**	0.7675	0.7639	0.7600	0.7548	0.7493	0.7418	
55°C		**g/mL**	0.7601	0.7565	0.7526	0.7475	0.7420	0.7345	
65°C		**g/mL**	0.7527	0.7491	0.7452	0.7401	0.7346	0.7272	
75°C		**g/mL**	0.7452	0.7416	0.7378	0.7327	0.7272	0.7198	
85°C		**g/mL**	0.7376	0.7341	0.7303	0.7252	0.7197	0.7123	
Kinematic Viscosity	**D445**								
100°C		**cSt**	0.70	0.68	0.70	0.71	0.71	0.73	
40°C		**cSt**	1.33	1.34	1.35	1.37	1.39	1.44	
-20°C		**cSt**	4.48	4.50	4.49	4.53	4.55	4.68	8.0 max
Lubricity (BOCLE)	**D5001**	**mm**	0.650	0.650	0.700	0.700	0.690	0.690	
Lubricity (HFRR) at 60°C	**D6079**	**µm**	731	749	704	653	746	725	
Fuel System Icing Inhibitor (FSII) Content @ 22 °C	**D5006**	**vol %**	0.08 (24°C)	0.09	0.09	0.09	0.09	0.09	0.07-0.10
Particulate Contamination in Aviation Fuels	**D5452**								
Total Contamination		**mg/L**	0.3	0.3	0.2	0.2	0.3	0.3	1.0 max

Table 4. Blend Results

Test	Method	Units	Sample ID CL14-6111 Results 15% ATJ	Sample ID CL14-6189 Results 25% ATJ	Sample ID CL13-5982 Results 35% ATJ	Sample ID CL13-5983 Results 50% ATJ	Sample ID CL13-6068 Results 65% ATJ	Sample ID CL13-5985 Results 85% ATJ	MIL-DTL-83133H (Table I and A-II)
Total Volume Used		**mL**	1000	1000	1000	1000	1000	1000	
Distillation	**D86**								
IBP		**°C**	172.9	173.0	172.6	173.1	173.9	173.7	
5%		**°C**	182.5	181.5	181.0	179.5	179.1	177.9	
10%		**°C**	184.7	183.5	181.8	180.7	180.3	178.3	205 max
15%		**°C**	187.0	185.3	182.6	181.7	180.8	179.2	
20%		**°C**	188.5	187.1	184.8	182.6	181.4	179.1	
30%		**°C**	193.5	191.3	188.3	185.9	183.7	180.9	
40%		**°C**	198.0	195.4	192.2	188.6	186.3	182.0	
50%		**°C**	202.6	199.6	196.1	192.4	188.0	183.3	
60%		**°C**	208.0	205.3	201.5	196.6	192.9	186.2	
70%		**°C**	214.9	212.3	208.4	203.6	197.8	189.3	
80%		**°C**	223.2	221.5	219.2	214.9	210.6	198.0	
90%		**°C**	234.8	233.8	232.5	231.4	232.1	222.9	
95%		**°C**	245.2	243.2	242.1	241.4	245.2	240.8	
FBP		**°C**	255.0	254.5	254.5	256.1	257.2	258.2	300 max
Residue		**%**	1.3	1.4	1.4	1.3	1.4	1.3	1.5 max
Loss		**%**	1.1	0.5	0.3	0.3	1.1	0.3	1.5 max
T50-T10		**°C**	17.9	16.1	14.3	11.7	7.70	5.0	15 min
T90-T10		**°C**	50.1	50.3	50.7	50.7	51.80	44.6	40 min
Flash Point (Pensky Martin)	**D93**	**°C**	56.5	51.5	49.5	49.5	50.5	49.5	38 min
Cetane Index	**D976**	**-**	49.9	50.2	50.3	51.0	51.5	52.6	
Particle Count by APC (Cumulative)	**ISO-4406**								
>= 4µm(c)		**class code**	16	18	16	17	15	17	
>= 6µm(c)		**class code**	15	16	15	16	12	15	
>= 14µm(c)		**class code**	11	14	12	12	8	12	
>= 21µm(c)		**class code**	10	14	11	11	0	10	
>= 38µm(c)		**class code**	7	13	7	7	0	0	
>= 70µm(c)		**class code**	0	13	0	0	0	0	
Heat of Combustion - Net Intermediate	**D4809**	**MJ/kg**	43.3	43.18	43.8	43.6	43.8	43.7	42.8 min
Sulfur-Mercaptan	**D3227**	**mass %**	0.0004	0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.002 max
Derived Cetane Number	**D6890**								
Ignition Delay, ID		**ms**	4.586	4.885	5.103	5.728	6.724	9.759	
Derived Cetane Number		**---**	45.15	42.66	41.02	37.04	31.89	24.50	40 min
Cetane Number	**D613**	**-**	44.2	41.0	36.4	32.0	26.7	<19.4	
MSEP	**D7224**	**rating**	60	55	67	72	71	69	70 min
Aromatic Content	**D1319**								
Aromatics		**vol %**	15.0	13.7	11.1	8.5	6.0	2.5	8.0-25.0
Olefins		**vol %**	1.6	2.1	2.9	2.0	2.9	2.5	
Saturates		**vol %**	83.4	84.2	86.0	89.5	91.1	95.0	
Naphthalene Content	**D1840**	**vol%**	0.66	0.51	0.50	0.40	0.27	0.12	3.0 max
Hydrogen Content (NMR)	**D3701**	**mass %**	14.26	14.51	14.63	14.85	15.04	15.23	13.4 min

Table 4. Blend Results

Test	Method	Units	Sample ID CL14-6111 Results 15% ATJ	Sample ID CL14-6189 Results 25% ATJ	Sample ID CL13-5982 Results 35% ATJ	Sample ID CL13-5983 Results 50% ATJ	Sample ID CL13-6068 Results 65% ATJ	Sample ID CL13-5985 Results 85% ATJ	MIL-DTL-83133H (Table I and A-II)
Sulfur Content	**D4294**	**ppm**	844	749	650	506	346	135	3000 max

Table 5. Speed-of-Sound and Bulk Modulus for Blends – 15, 25, 35% ATJ

Sample ID CL14-6111 Results			Sample ID CL14-6189 Results			Sample ID CL13-5982 Results		
15% ATJ			**25% ATJ**			**35% ATJ**		
Pressure (psi)	**Speed-of-Sound (m/s)**	**Bulk Modulus (psi)**	**Pressure (psi)**	**Speed-of-Sound (m/s)**	**Bulk Modulus (psi)**	**Pressure (psi)**	**Speed-of-Sound (m/s)**	**Bulk Modulus (psi)**
35°C								
184	1247.4	174,382	413	1247.4	173,700	184	1231.4	168,272
718	1270.3	181,466	870	1269.4	180,522	832	1260.1	177,035
1519	1307.9	193,344	1710	1307.8	192,639	1633	1292.7	187,320
2091	1324.3	198,919	2473	1329.8	200,043	2320	1317.6	195,412
3007	1358.3	210,430	3846	1378.7	216,736	3770	1373.5	214,167
4075	1393.4	222,741	4838	1421.4	231,626	4761	1405.5	225,450
4838	1418.2	231,613				5601	1426.1	233,109
5715	1445.5	241,702						
75°C								
336	1102.2	131,146	222	1093.6	128,337	222	1089.5	126,764
603	1116.8	134,958	794	1116.4	134,404	1557	1150.8	143,138
1328	1151.5	144,409	1519	1151.1	143,772	2358	1187.3	153,334
2091	1184.1	153,580	2511	1192.7	155,554	3045	1218.5	162,304
2740	1216.0	162,764	2892	1215.1	161,877	3655	1235.2	167,543
3388	1242.3	170,648	3541	1234.0	167,659	4761	1282.9	182,045
4647	1283.4	183,555	4609	1281.5	182,077	5334	1305.1	189,079
5448	1311.4	192,552	222	1093.6	128,337			

Table 6. Speed-of-Sound and Bulk Modulus for Blends – 50, 65, 85% ATJ

Sample ID CL13-5983 Results			Sample ID CL13-6068 Results			Sample ID CL13-5985 Results		
50% ATJ			65% ATJ			85% ATJ		
Pressure (psi)	Speed-of-Sound (m/s)	Bulk Modulus (psi)	Pressure (psi)	Speed-of-Sound (m/s)	Bulk Modulus (psi)	Pressure (psi)	Speed-of-Sound (m/s)	Bulk Modulus (psi)
35°C								
222	1223.6	165,157	260	1215.3	161,598	184	1187.8	152,768
832	1246.7	172,176	718	1231.0	166,354	603	1214.4	160,175
1900	1291.8	186,184	1633	1270.3	178,359	1519	1247.6	170,195
2816	1323.5	196,538	2854	1317.2	193,230	2320	1282.9	180,942
3732	1364.7	210,057	3388	1332.7	198,454	3541	1330.1	196,019
4723	1394.8	220,659	4494	1378.0	213,486	4266	1357.7	205,090
5868	1425.4	231,864	5715	1419.1	227,872	4876	1378.6	212,228
			6402	1450.8	239,024	6058	1418.5	226,027
75°C								
184	1069.3	121,184	222	1062.4	118,766	260	1042.3	113,190
832	1102.4	129,701	909	1097.4	127,597	718	1066.3	118,998
1519	1133.8	137,967	1443	1113.9	132,079	1328	1102.5	127,979
2167	1168.1	147,208	1977	1149.5	141,323	1786	1114.7	131,317
2892	1194.8	154,901	2663	1174.7	148,407	2435	1151.1	140,884
3884	1234.5	166,530	3350	1202.8	156,304	3312	1194.8	152,768
4990	1282.9	181,160	4113	1234.8	165,715	4189	1230.6	163,113
5944	1312.1	190,696	5181	1282.9	180,188	5219	1271.5	175,328
			6135	1311.6	189,367	5830	1294.5	182,558

Table 7. Re-Blend Results

Test	Method	Units	SwRI Sample ID CL14-6165 Results	SwRI Sample ID CL14-6166 Results	SwRI Sample ID CL14-6167 Results	SwRI Sample ID CL14-6168 Results	SwRI Sample ID CL14-6169 Results	SwRI Sample ID CL14-6170 Results	SwRI Sample ID CL14-6171 Results	MIL-DTL-83133H (Table I and A-II)
			0% ATJ	15% ATJ	35% ATJ	50% ATJ	65% ATJ	85% ATJ	100% ATJ	
Water Reaction	**D1094**									
Volume change of aqueous layer		**mL**	1.0	1.0	0.0	1.0	0.5	1.0	1.0	
Interface condition		**rating**	1b	1b	1b	1b	1b	1b	1b	1b max
Separation		**-**	2	2	2	2	2	2	2	
Electrical Conductivity	**D2624**									
Temperature		**°C**	22.1	23.3	21.8	22.4	21.9	21.8	21.8	
Electrical Conductivity		**pS/m**	420	750	750	590	300	550	0	150-600
Density	**D4052**									
15°C		**g/mL**	0.7948	0.7893	0.7819	0.7763	0.7706	0.7634	0.7575	0.775-0.840
Fuel System Icing Inhibitor (FSII) Content @22°C	**D5006**	**vol %**	0.09	0.09	0.09	0.09	0.09	0.08	0.00	0.07-0.10
MSEP	**D7224**	**rating**	69	48	61	58	65	72	90	70 min

Table 8. Re-Blend Results using new Stadis 450 Sample

Test	Method	Units	SwRI Sample ID CL14-6403 Results	SwRI Sample ID CL14-6404 Results	SwRI Sample ID CL14-6405 Results	SwRI Sample ID CL14-6406 Results	SwRI Sample ID CL14-6407 Results	SwRI Sample ID CL14-6408 Results	MIL-DTL-83133H (Table I and A-II)
			0% ATJ	15% ATJ	35% ATJ	50% ATJ	65% ATJ	85% ATJ	
Electrical Conductivity	**D2624**								
Temperature		**°C**	21.0	21.2	20.3	19.8	19.9	19.7	
Electrical Conductivity		**pS/m**	493	1109	814	770	471	852	150-600
Density	**D4052**								
15°C		**g/mL**	0.7948	0.7894	0.7820	0.7763	0.7707	0.7633	0.775-0.840
MSEP	**D7224**	**rating**	70	61	70	71	79	73	70 min

4.0 CONCLUSIONS

The objective of this was task was to generate baseline data for ATJ/JP-8 blends to support testing related to ground vehicles and equipment. Other than the odd response of the blends toward the static dissipator additive, most other properties showed a linear trend relative to the blending that one might expect from hydrocarbons. The issue with the static dissipator additive was not studied further under this effort. It may simply be an issue with the particular sample of additive that was available on-hand. A brief additive response study could resolve that concern. The blend proportions provided a good span of important properties such as density, cetane number, and aromatic content. This matrix of data made it possible to select candidate blend ratios for further study in engines and fuel pumps under this WD. The data provided herein and the subsequent hardware evaluations will contribute to the overall approval process for ATJ fuels.